MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023 (TERM ID 2220)

PME0016 MECHANICS

(Foundation in Engineering)

3 JULY 2023
9:00 A.M. – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 4 pages, excluding the appendixes.
2. Answer all questions.
3. Write your answers in the answer booklet provided.
4. Show all relevant steps to obtain maximum marks.

Question 1 (10 marks)

a) i) Provide the meaning of torque. Draw a simple diagram to show how you can calculate the torque of a force and write the related equation.

[3 marks]

ii) Under what conditions are torques positive and negative?

[2 marks]

b) A uniform, 150-N pipe is used as a lever, as shown in Figure Q1. Find x (in terms of L) if a 610-N weight at the right end is to balance a 270-N weight at the left end. What is the reaction force exerted by the support (fulcrum) on the pipe? Draw the free body diagram for the pipe.

[5 marks]

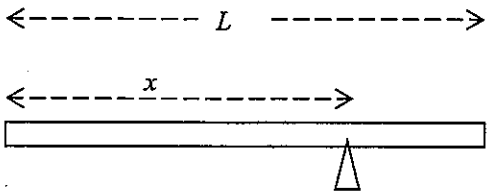

Figure Q1

Question 2 (10 marks)

a) Two water slides at a pool are shaped differently, but start at the same height h as shown in **Figure Q2(a)**. Two riders, Paul and Kathleen, start from rest at the same time on different slides.

i) Which rider, Paul or Kathleen, is traveling faster at the bottom? Explain.

[2 marks]

ii) Which rider makes it to the bottom first? Explain.

[2 marks]

Ignore friction and assume both slides have the same path length.

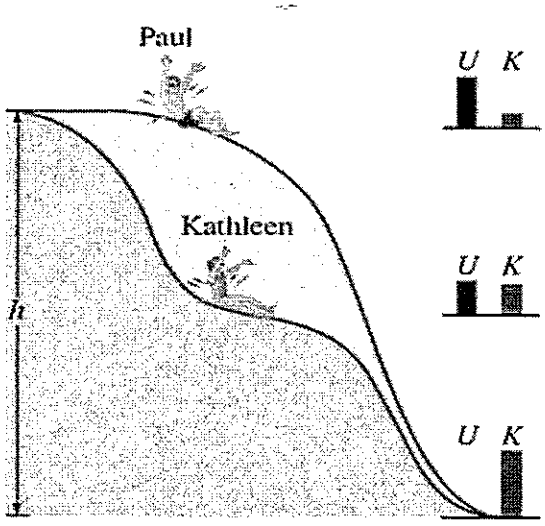

Figure Q2(a)

Continued...

b) A ball of mass $m = 2.60$ kg, starting from rest, falls a vertical distance $h = 55.0$ cm before striking a vertical coiled spring, which is then compressed by an amount of $Y = 15.0$ cm as in **Figure Q2(b)**. By assuming the spring has negligible mass, and ignore air resistance, determine:

i) the speed of the ball when it hits the spring.

[2 marks]

ii) the spring constant.

[2.5 marks]

iii) the work done by the spring.

[1.5 mark]

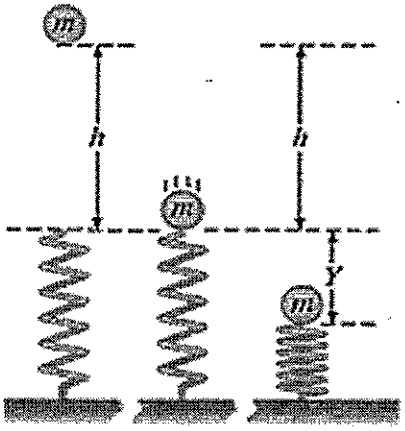

Figure Q2(b)

Question 3 (15 marks)

a) State or explain the following law, principle or term:

i) Elastic limit [1 mark]

ii) Archimedes' principle [1 mark]

b) A man whose weight is 0.80 kN is standing upright. By approximately how much is his femur (thighbone) shortened compared to when he is lying down? Assume that the compressive force on each femur is about half his weight. The average cross-sectional area of the femur is 8.0 cm^2 and the length of the femur when lying down is 43.0 cm. Given that the Young's modulus for a femur in compression is $Y = 9.4 \times 10^9$ Nm^{-2}.

[3 marks]

Continued...

c) Figure Q3(a) shows a light spring with a spring constant k of 300 Nm^{-1} resting vertically at the bottom of a large beaker of water (the density of water is 1000.0 kgm^{-3}). A 5.0-kg block of wood with density of 650.0 kgm^{-3} is connected to the spring and the block-spring system is allowed to reach static equilibrium.

i) Determine the volume of the wood block. [1 mark]

ii) Determine the buoyant force acting on the wood block. [1 mark]

iii) Calculate the net force on the spring. [1 mark]

iv) What is the elongation, x, of the spring? [1 mark]

v) State what happen (remain the same, increase or decrease) to the elongation of the spring in part (iv) if :

1. just the water is replaced by another liquid higher in density. [1 mark]

2. just the wood is replaced by another material of same mass but bigger in volume than the wood block. [1 mark]

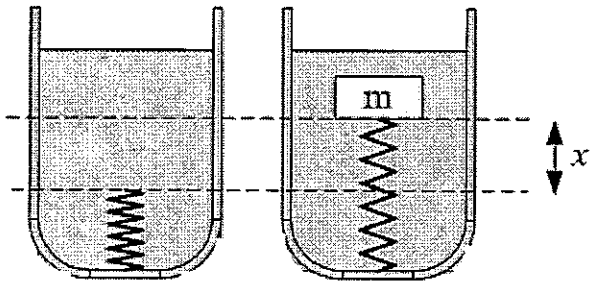

Figure Q3(a)

d) Figure Q3(b) shows a graph of stress versus strain. Complete the graph by naming the points labelled *a*, *b*, *c* , *d* on the graph and give a brief description for each point. [4 marks]

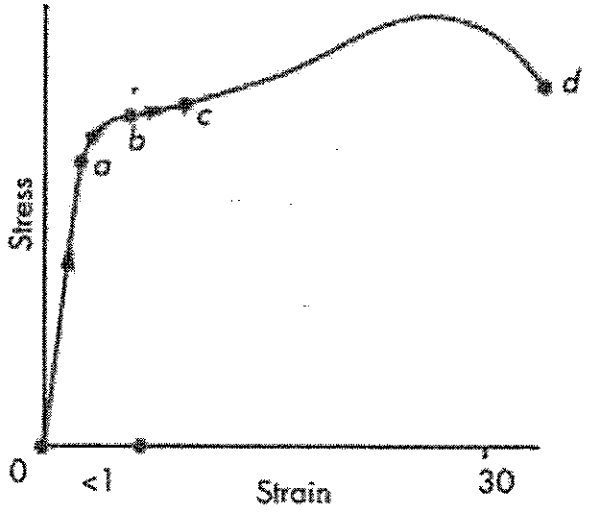

Figure Q3(b)

Continued...

Question 4 (15 marks)

a) A 0.50-kg object connected to a light spring with a spring constant of 20 N/m oscillates on a frictionless horizontal surface.

i) Calculate the total energy of the system and the maximum speed of the object if the amplitude of the motion is 3.0 cm.

[3.5 marks]

ii) What is the velocity of the object when the displacement is 2.0 cm?

[2 marks]

iii) Compute the kinetic and potential energies of the system when the displacement is 2.0 cm. [2 marks]

b) An object with mass of 1 kg is vibrating at the end of a spring. If the equation for its position x (in meter) as a function of time t (in seconds) is $x = 0.25\cos(\pi t/8)$. Find the:

i) amplitude, frequency and period of the motion. [2.5 marks]

ii) angular frequency, ω. [1 mark]

iii) magnitude of the maximum velocity, v_{max}. [1 mark]

iv) spring constant, k. [1 mark]

v) velocity, v and acceleration, a as a function of time. [2 marks]

End of page

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.602×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N.m^2 kg^{-2}
Universal gas constant,	R	=	8.314 J/K.mol
Hydrogen ground state,	E_o	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J.s
		=	4.14×10^{-15} eV.s
Speed of light in vacuum,	c	=	3.0×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	=	9.81 m s^{-2}
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_o	=	1.0×10^{-12} W m^{-2}
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_o}$	=	9.0×10^9 N m^2 C^{-2}
Permittivity of free space,	ε_o	=	8.85×10^{-12} C^2 N^{-1} m^{-2}
Permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ (T.m)/A
1 atmosphere pressure,	1 atm	=	1.0×10^5 N/m^2
			1.0×10^5 Pa
Earth: Mass,	M_E	=	5.98×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),	R_{ES}	=	149.6×10^6 km
Earth-Moon distance (mean),	R_{EM}	=	385×10^3 km

LIST OF FORMULA

Differential Rule

$$y = kx^n$$

$$\frac{dy}{dx} = knx^{n-1}$$

Trigonometric Identity

$$sin = \frac{opposite}{ypotenuse} \qquad cos = \frac{adjacent}{ypotenuse} \qquad tan = \frac{opposite}{adjacent}$$

$$\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$$

$$\sin(\alpha-\beta) + \sin(\alpha+\beta) = 2\sin\alpha\cos\beta$$

NEWTONIAN MECHANICS

$$P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = Fv$$

$$KE = \frac{1}{2}mv^2 \qquad PE_s = \frac{1}{2}kx^2 \qquad F_s = -kx \qquad PE_g = mg$$

$$T_s = 2\pi\sqrt{\frac{m}{k}} \qquad T_p = 2\pi\sqrt{\frac{l}{g}} \qquad \omega = \sqrt{\frac{k}{m}} \qquad \omega = \sqrt{\frac{g}{l}}$$

$$T = \frac{2\pi}{\omega} = \frac{1}{f} \qquad v_{max} = \omega A \qquad a_{max} = \omega^2 A \qquad E_T = \frac{1}{2}kA^2$$

$$v = \omega\sqrt{A^2 - x^2} \qquad a = -\frac{k}{m}x$$

$$x = A\cos\omega t \qquad x = A\sin\omega t$$
$$v = -\omega A\sin\omega t \qquad v = \omega A\cos\omega t$$
$$a = -\omega^2 A\cos\omega t \qquad a = -\omega^2 A\sin\omega t$$

$$\rho = m/V \qquad P = F/A \qquad B = \rho gV \qquad P = \rho gh$$

$$Y = \frac{FL_o}{A\Delta L} \qquad \sum W = \Delta KE \qquad \tau = Fd \qquad F = ma$$